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DESIGN OF BROADBAND DIAMOND-SHAPED MICROSTIP PATCH ANTENNA

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ABSTRACT

Microstrip patch antenna presented here is a single-patch broadband Diamond-shaped patch antenna. Feeding used for this work is coaxial feeding. In this antenna two rectangular slots are inserted so the patch looks like Diamond Shape. Bandwidth of antenna is increased using slot and rectangular patch. The proposed antenna is operating at centre frequency of 4.3GHz (i.e. near to 4.5 GHz). Diamond shaped antenna gives bandwidth more than 12% for $|S_{11}| \leq 10$ dB ranging from 4.029 to 4.628 GHz. VSWR of this antenna is 1.226 which is within the range of 1-2 at resonant frequency 4.3GHz. From the analysis of simulated results it can be seen that the antenna is best suitable for C-band, UWB and are suited to digital wireless communication.

KEYWORDS: Microstrip Antenna, Return Loss, Diamond-Shape, VSWR, Patch, Ground Plane

INTRODUCTION

MSA was first proposed by G.A Deschamps in 1953,but didn’t become practical when it was developed further by researchers such as Robert E.Munson[4] .MSA is a narrow band antenna fabricated by etching the antenna element pattern in metal trace bonded to an insulating dielectric substrate, such as a printed circuit board, with a continuous metal layer bonded to the opposite side of the substrate which forms a ground plane. Common microstrip antenna shapes are square, rectangular, circular and elliptical, but any continuous shape is possible. Some patch antennas do not use a dielectric substrate and instead made of a metal patch mounted above a ground plane using dielectric spacers; the resulting structure is less rugged but has a wider bandwidth. Because such antennas have a very low profile, are mechanically rugged and can be shaped to conform to the curving skin of a vehicle, they are often mounted on the exterior of aircraft and spacecraft, or are incorporated into mobile radio communications device [1], radar for missiles and telemetry [1], global positioning systems (GPS) [2], mobile handheld radios or communication devices [2], and wireless communication system. But the microstrip antennas also have some disadvantages, such as narrow bandwidth, low gain and the excitation of surface waves.

Many techniques are used to increase the bandwidth of MSA, such as by increasing substrate thickness, by using a low dielectric substrate, by using slot into patch, using various impedance matching techniques, and also using multiple resonators [2-6]. Generally the bandwidth and the size of an antenna are mutually interrelated i.e. if we improve one of the characteristic then the other characteristic is normally degraded. In this paper authors presented microstrip Diamond-shaped patch antenna using a thick dielectric substrate having a low dielectric constant which provides better efficiency, larger bandwidth at centre frequency 4.5GHz. A thick dielectric substrate increases the fringing field at the patch periphery like low dielectric constant and thus increases the radiated power. Microstrip Diamond-shaped patch antenna is design by inserting two slots into rotated square patch. These slots also increase the bandwidth of antenna.

DIAMOND-SHAPED MSA

The Design geometry of MSA Diamond-shaped patch is illustrated in Figure 1. The proposed antenna has a simple configuration and is consisting of rotated square patch. This antenna consists of two substrates having thickness 5mm. The first substrate, above the ground plane is consisting of FR4 of dielectric constant 1.07 with height 3.4mm and second substrate with height 1.6mm whose dielectric constant is 4.4.Total thickness of 5mm. A rotated square patch is implemented on this layer and two slots of 30mm × 2mm are inserted into the patch. The coaxial feed is used here for excitation at center position (0.1, 0.1). The ground plane size of 62mm × 62mm is chosen for t**h**is design. The antenna is designed and simulated using MOM environment IE3D software .To increase the bandwidth of proposed antenna, slot and thick substrate is used.

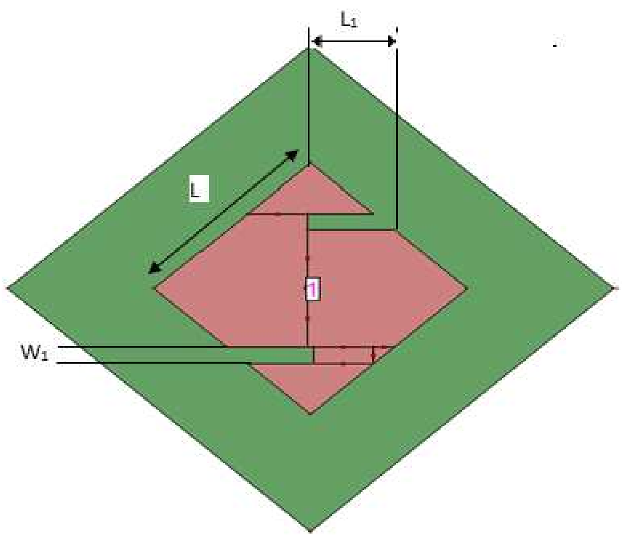


Figure 1: Designed Diamond-Shaped Patch Antenna

METHODOLOGY

For designing MSA important parameters are Dielectric substrate its constant, height of substrate and resonant frequency For designing Diamond shaped patch antenna first ground plane size is fixed then centre frequency and substrate is decided and finally optimized dimensions for length and width of patch is taken then further simulation is done on MOM using IE3D.Selection of slot length and width is done on actual basis, also feeding is done to match impedance usually at 50ohm.

Calculation of the Width (W)

The width of the Microstrip patch antenna is given by, as expressed in [7]

$$W = \frac{c}{2f\sqrt{\frac{(\varepsilon_r + 1)}{2}}} \tag{1}$$

The width of proposed patch antenna was calculated by using (1) W=32.765mm, where c is the speed of light.

Calculation of Effective Dielectric Constant (ε_{reff})

The effective dielectric constant is given by, as expressed in [7]

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1+12\frac{h}{W}\right]^{-1/2} \tag{2}$$

The effective dielectric constant was calculated by using (2) $\varepsilon_{reff} = 1.056$.

Calculation of the Length Extension (ΔL)

The extended length of the patch is given by, as expressed in [7]

$$\Delta L = 0.412h\frac{(\varepsilon_{reff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{reff}-0.258)\left(\frac{W}{h}+0.8\right)} \tag{3}$$

The extended length of patch was calculated by using (3) $\Delta L =$ 3.245mm.

Calculation of the Effective length (L_{eff})

The effective length of patch is given by, as expressed in [7]

$$L_{eff} = \frac{c}{2f\sqrt{\varepsilon_{reff}}} \tag{4}$$

The effective length of patch was calculated by using (4)

L_{eff} = 32.437mm.

Calculation of the resonant length of patch (L*)*

The actual length of the patch is given by, as expressed in [7]

$$L = L_{eff} - 2\,\Delta L \tag{5}$$

This comes out to be 25.947mm.

Finally selected optimized dimensions are size of patch is 32mm × 32mm. and size of ground plane is 62mm × 62mm

RESULTS & DISCUSSIONS

When whole power is not delivered to the load it indicates load mismatch and so it called loss i.e. return of power and this loss of returned power is also called return loss. The bandwidth is a range of frequencies over which return loss is less than -10dB. The S_{11} scattering parameter (return loss) of microstrip Diamond-shaped patch antenna is shown in Figure 2 and measured return loss is -19dB and the measured bandwidth of the antenna is 527MHz, which is over 12% for $|S_{11}| \leq 10$ dB ranging from 4.036 to 4.553GHz. The VSWR plot for coaxial feed antenna is shown in Figure 3. The value of VSWR is 1:1.224. VSWR is lie in the range of 1-2 which has been achieved for the frequency 4.3GHz, which is near the operating frequency value. In order to match perfectly the antenna impedance should be close to 50Ω.The impedance for this antenna is 50.05Ω which is shown in Smith Chart figure 4.

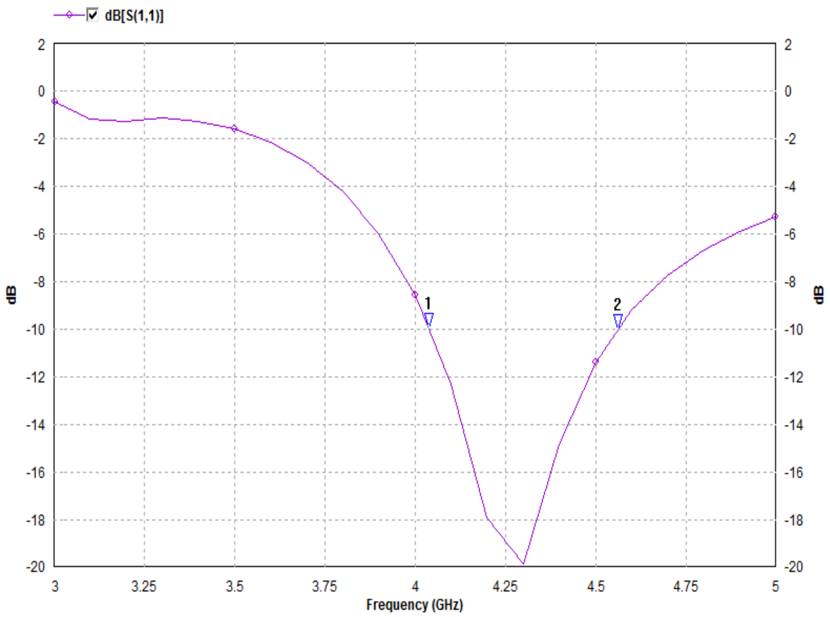
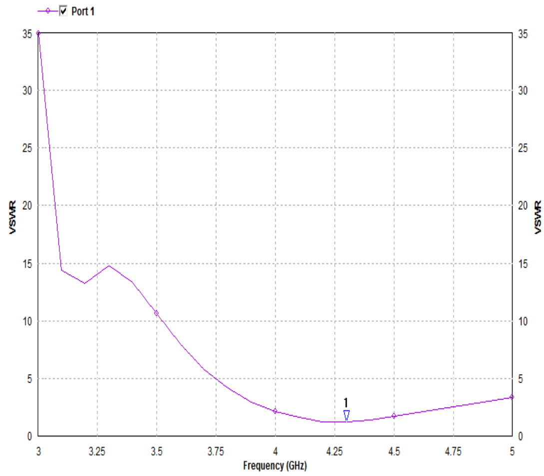


Figure 2: Return loss v/s Frequency



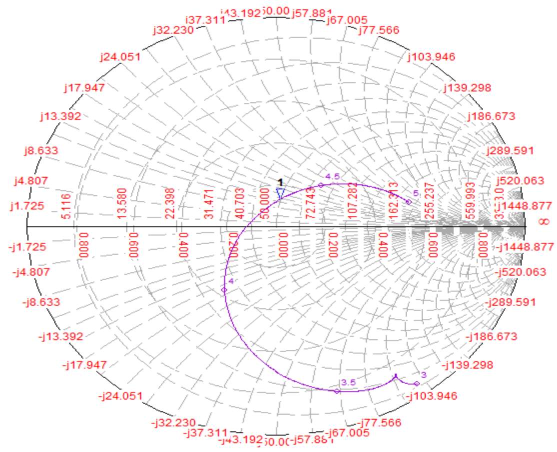


Figure 3: VSWR v/s Frequency **Figure 4: Smith Chart**

CONCLUSIONS

For proposed paper, the design of a microstrip Diamond-shaped patch antenna is shown Having the coaxial feeding for excitation covering the 4.036 - 4.553GHz frequency spectrum. The Diamond-shaped patch antenna provides a bandwidth of approximately 12% which is greater than simple microstrip patch bandwidth near about 4-5%. It shows a good impedance matching of 50.05Ω which is close to 50 Ω at the resonant frequency 4.3GHz. Finally the antenna attains a bandwidth of 527MHz. the analysis of simulated results shows that it can be best suitable for C-band and UWB frequency. At operating of 4.3GHz .this antenna is best applicable to modern communication devices and wireless communication frequencies

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